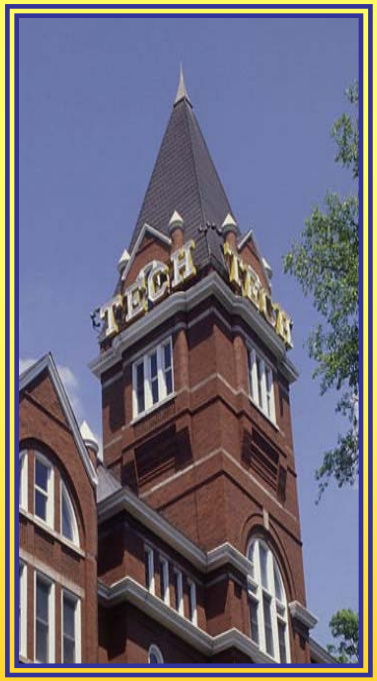
Strategic and Technical Implementation Challenges of Advancing Front-End IAEA Safeguards



Shaheen Azim Dewji
Nuclear and Radiological Engineering Program
Georgia Institute of Technology
shaheen.dewji@gatech.edu

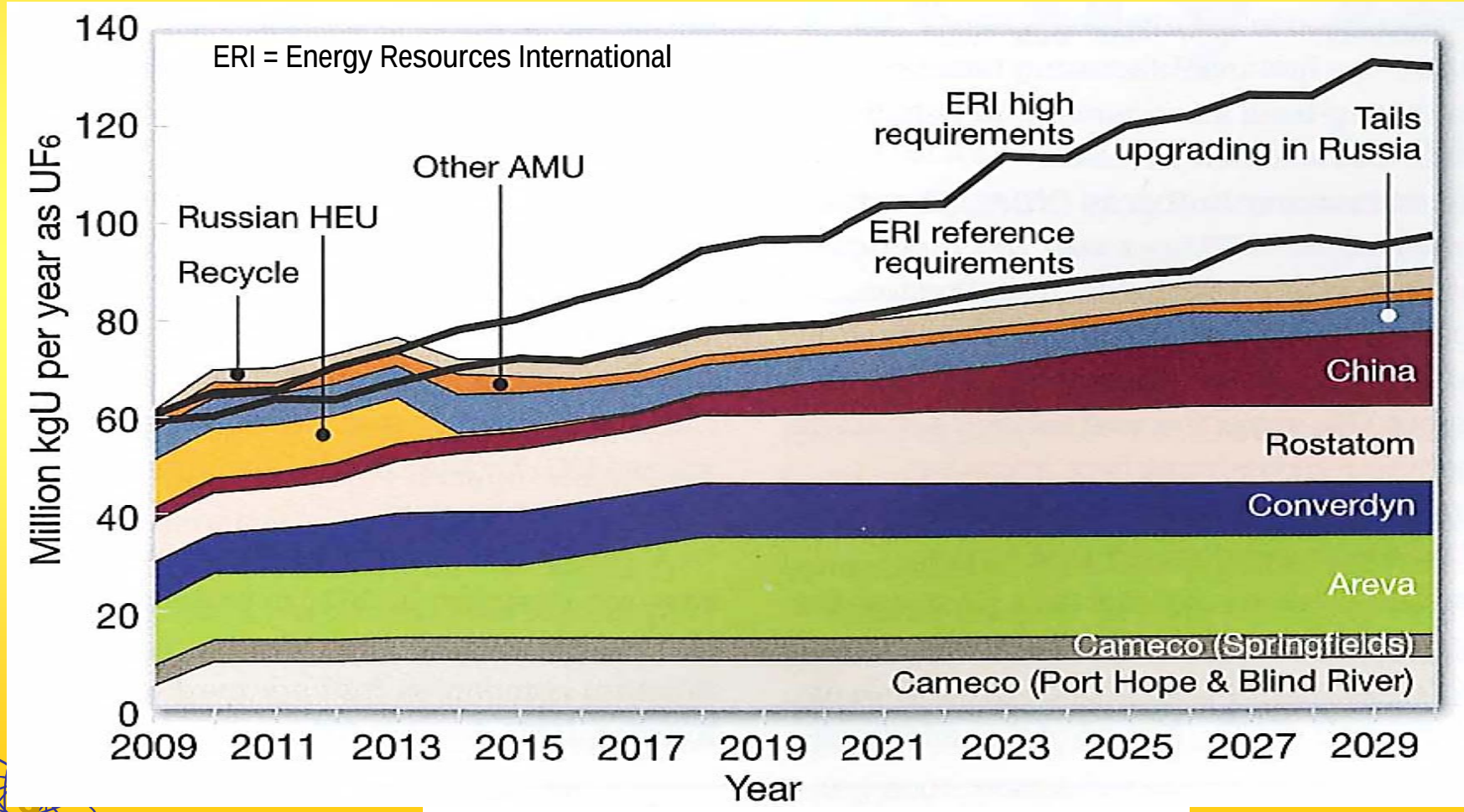
IAEA Governance and Reform
IGCC Nuclear Security D.C. Policy Series
February 24, 2012

Outline

- **Background**
  - Fuel Cycle Demands
  - Conversion Process
- **IAEA Safeguards Practices**
- **Technical Challenges**
  - Diversion Pathways
- **Policy Challenges**
  - Stakeholders
  - State Responses
- **Evaluating the Dynamic of the Safeguards Regime**

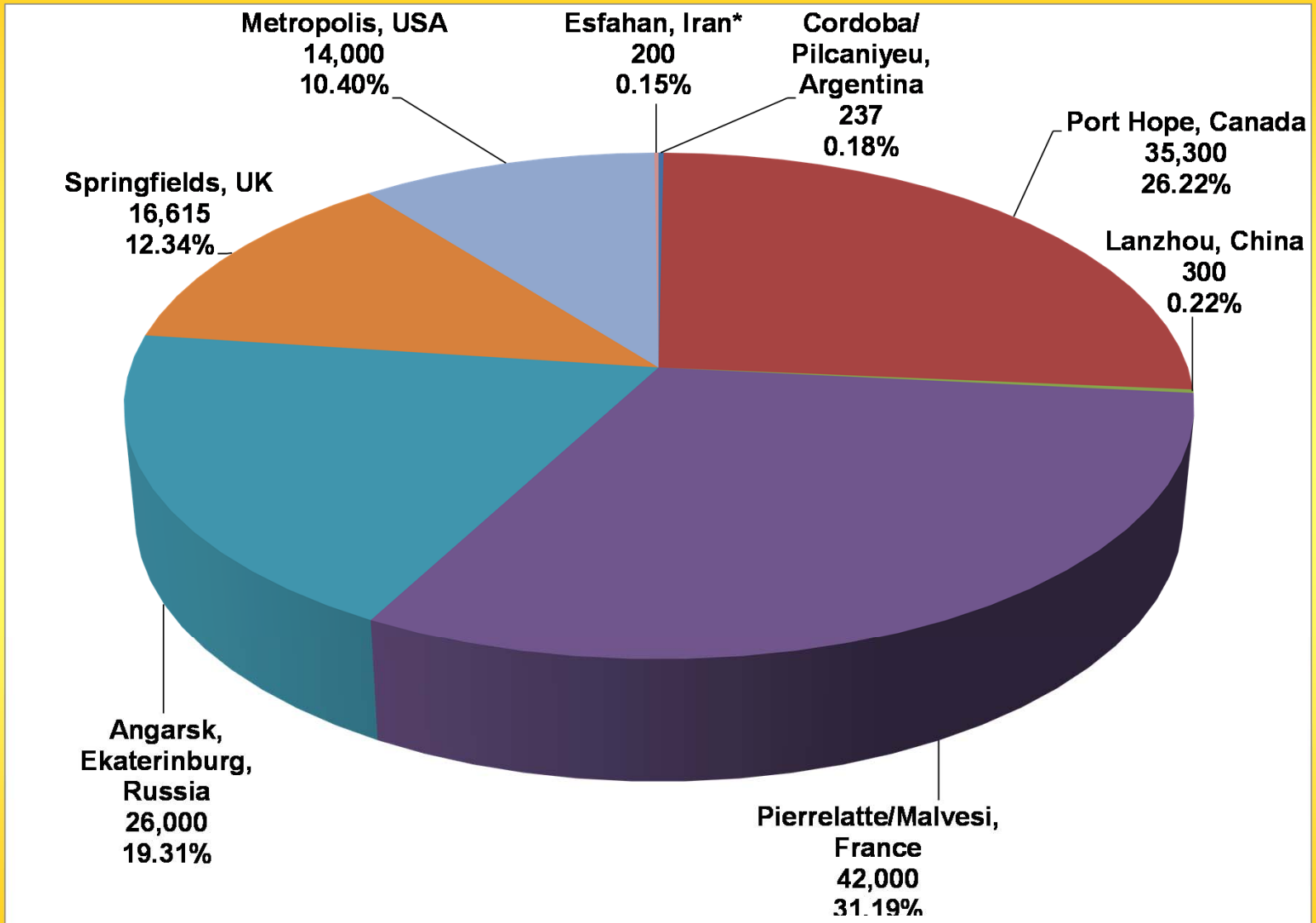
Background: Fuel Cycle Demands

- Worldwide, conversion facilities produce 76,000 MTU per year
- Fuel for growing number of nuclear power plants (~495)



Source: Nuclear Engineering International, September 2010

Background : Current Global Capacity (MTU/yr.)



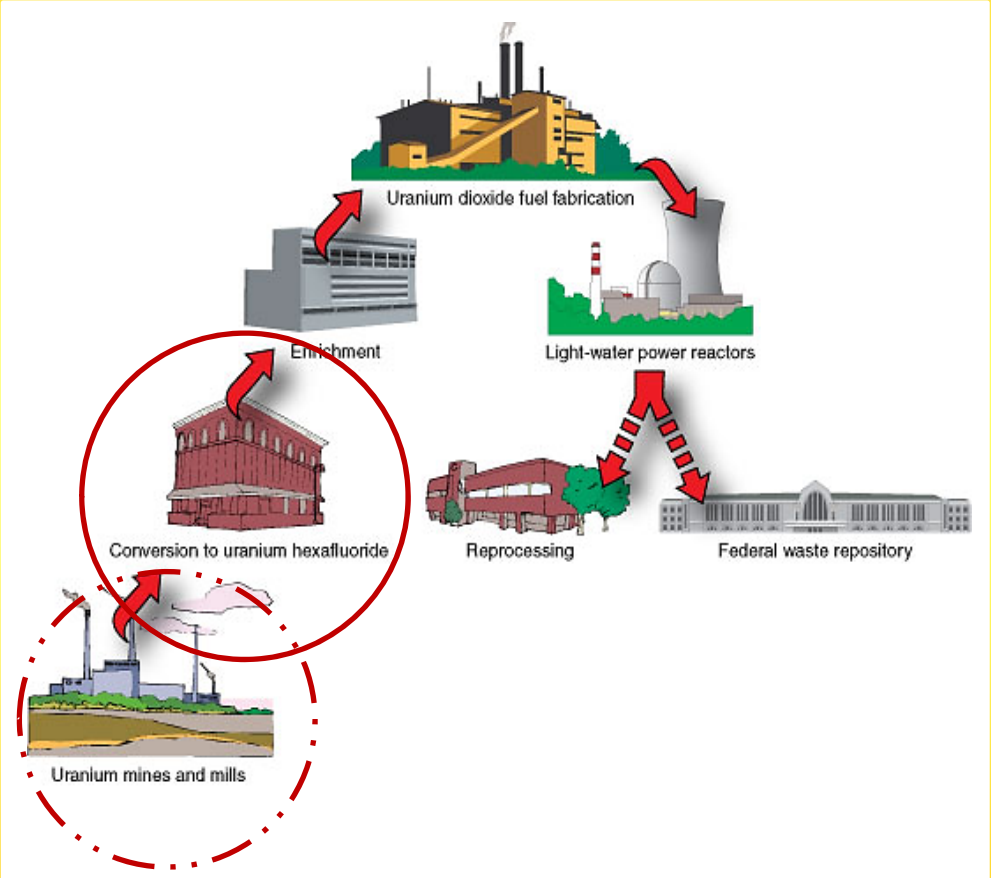
Source: *International Atomic Energy Agency, "Nuclear Fuel Cycle Information System," IAEA-TECDOC-1613, 2009.*

Background : Projected Construction

Country	Facility Name	Facility Type	Scale	Design Capacity (MTU/y)	Start of Operation
Brazil	BRW Conversion	Conversion to UF6	Pilot plant	40	2013
France	Comurhex II - Malvesi (UF4)	Conversion to UF4	Commercial	15000	2012
France	Comurhex II - Pierrelatte (UF6)	Conversion to UF6	Commercial	15000	2012

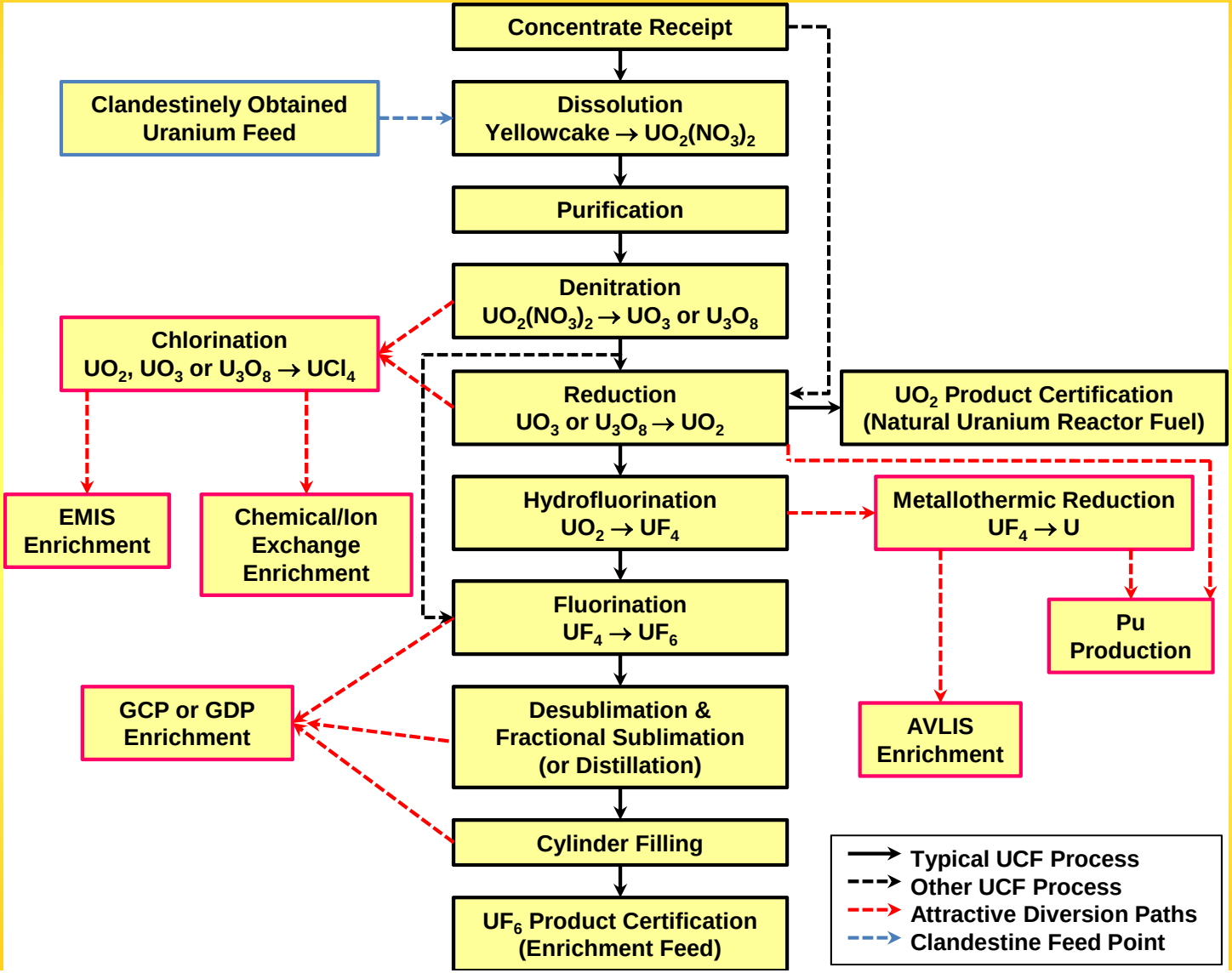
Source: *International Atomic Energy Agency, "Nuclear Fuel Cycle Information System," IAEA-TECDOC-1613, 2009.*

Background : Front-End of the Fuel Cycle



- **Conversion is a series of chemical processes operations in which impurities are removed**
- Feed for NUCPs is in form of **ore concentrate (UOC)**
  - Contains 75–80% U_3O_8
- Convert the U_3O_8 to gaseous UF_6 for enrichment or UO_2 for fuel fabrication

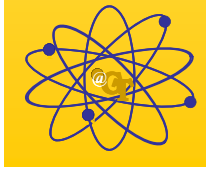
Background: Wet Solvent Conversion & Potential Diversion Paths for NUCPs



Source: R. L. Faulkner, *et al.*, "Oak Ridge Efforts to Enhance Conversion Plant Safeguards," in *45th Annual Meeting of the Institute of Nuclear Materials Management (INMM)*, Orlando, FL, 2004.

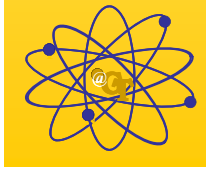
IAEA Safeguards
Monitoring Earlier in the Fuel Cycle

- **Two principal products from NUCPs fall under IAEA safeguards**
  - **UF_6 :** Feedstock for subsequent enrichment at commercial facilities.
  - **UO_2:** Fuel in heavy-water-moderated reactors (CANDU)
    - Light water reactors (limited).



IAEA Safeguards
Monitoring Earlier in the Fuel Cycle

- **Until 2003, IAEA not historically considered conversion under safeguards.**
- **Policy Paper 18** *(IAEA, 2009)* **"Safeguards Measures Applicable in Conversion Plants Processing Natural Uranium"**
  - **Purified aqueous uranium solution (uranyl nitrate [UN]) or uranium oxides.**
  - **Material for isotopic enrichment or fuel fabrication.**
  - **Safeguards procedures no later than the first point in the conversion process.**

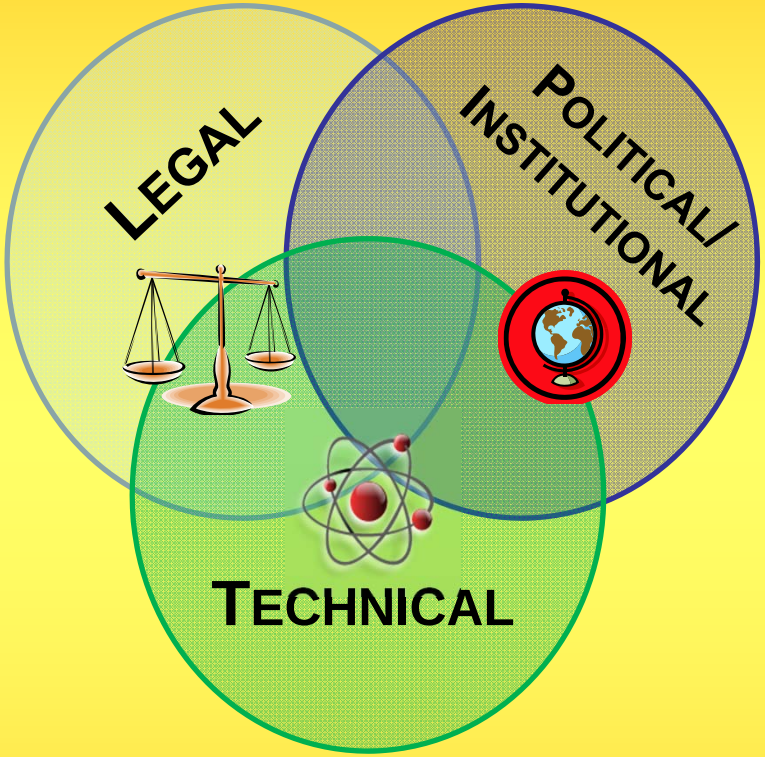


IAEA Safeguards
Monitoring Earlier in the Fuel Cycle

INFCIRC/153 (Corrected) Paragraph 34(c)

(c) When any nuclear material of a composition and purity suitable for fuel fabrication or for being isotopically enriched leaves the plant or the process stage in which it has been produced, or when such nuclear material, or any other nuclear material produced at a later stage in the nuclear fuel cycle, is imported into the State, the nuclear material shall become subject to the other safeguards procedures specified in the Agreement.

The Evolving Dynamic…



- Majority of current conversion capacity in nuclear weapons states (NWS) ~75%.
- Projected construction in non-nuclear weapons states (NNWS).
- **Dynamic trends in the evolution of current safeguards policy in anticipation/response to technology development.**

Technical Challenges: IAEA Safeguards Policy Paper 18

- **Safeguards Objective: Timely detection of diversion of one Significant Quantity (SQ)**
- **NUCPs: 1SQ = 10MTU/year with a 50% probability of detection** *(Boyer et al. 2004)*
- Ideally, continuous presence or continued monitoring of unattended monitoring systems by IAEA inspectors would be effective.
- Resource shortages require alternative technological framework + Short Notice Random Inspections (SNRI).
  - Operator “Mailbox” declarations of specified nuclear material quantities and operating parameters on a periodic basis.

Technical Challenges : Categories of Diversion

- **Material substitution:** Substitution of feed materials with higher-than-declared uranium content. Uranium concentration is either understated in the product/feed streams or overstated in the waste stream; substitution of dummy product materials.

- **Equipment alteration:** Operating procedures and/or equipment configurations are modified to alter the physical uranium output quantity.

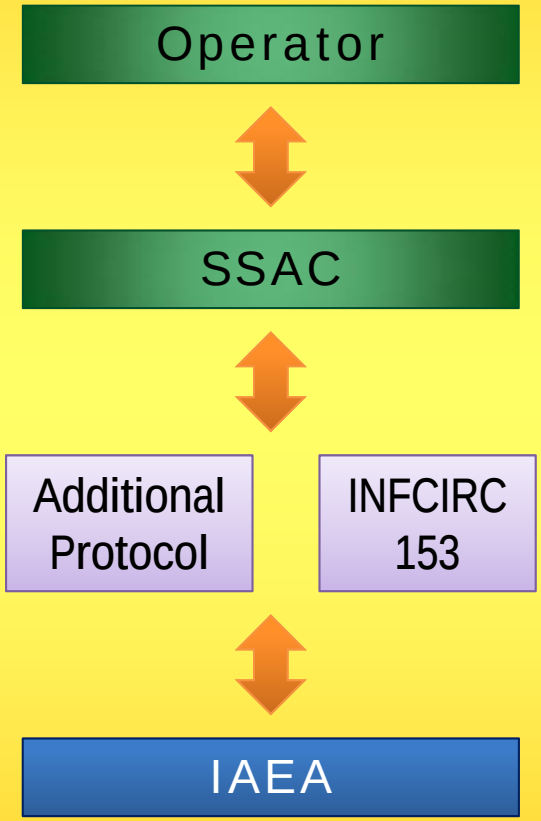
- **Falsification of records and/or data tampering:** Material balance records are adjusted, such as understating throughput, or incorrectly recorded to reinforce diversion activities.

Technical Challenges: Categories of Diversion

1. **Processing batch of undeclared UOC**
2. **Substitution of stored materials with undeclared UOC**
   - **Introduction of undeclared UOC into dissolution vessel**
   - **Introducing undeclared UOC during recycle processing**
3. **Substituting full with empty UF6 cylinders**
4. **Manipulation of declared amounts of U in waste streams and *Material Unaccounted For* (MUF)**

Source: *D. Nusbaum, Z. Karpas, Y. Sadan, G. Reich, J. Bedell, S. LaMont, J. Phillips, R. Goorevich. "Strengthening Safeguards in the Nuclear Fuel Cycle: 1. Diversion Scenarios in the Nuclear Fuel Cycle". 8th International Conference on Facility Operations – Safeguards Interface, 2008.*

Policy Challenges: Balancing Stakeholder Interests



1. **Dynamic between technical capabilities, political will, resource optimization and effectiveness (economic, technical, strategic) for all stakeholders (IAEA, State, Operator).**
2. **How does this address current/future players**
   - **Demand:** UAE, China, Brazil, Indonesia
   - **Supply**: Kazakhstan
   - **Security**: Iran

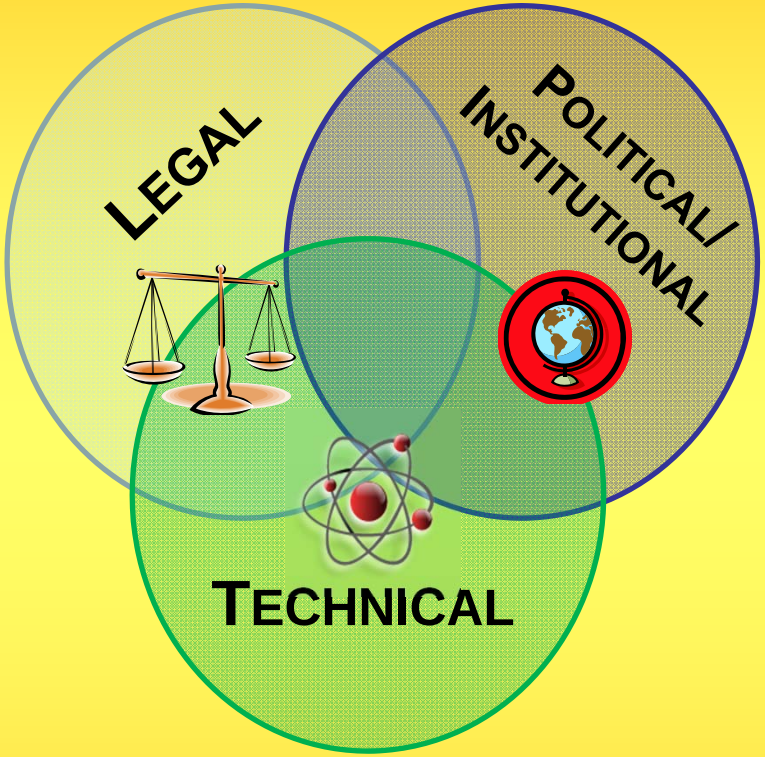
Policy Challenges: ABACC - Brazilian Argentine Agency for Accounting and Control of Nuclear Materials

- Conversion plants for Brazil and Argentina have different process routes
  - Quadripartite Agreement defines precisely where are the starting points of the safeguards and the requirements for any changes on these definitions.
- Policy Paper 18 are beyond the legal framework of the Quadripartite.
- Strengthen the control on the first step where the nuclear material becomes pure (pure uranyl nitrate), without changing the interpretation of starting point of safeguards under the current legal framework.
- Employ use of non-invasive safeguards tools like DIV and Short Notice Random Inspections (SRNI).
- Non-Signatories to Additional Protocol

Policy Challenges: CNSC-Canadian Nuclear Safety Commission

- Verifications that recently took place in July 2006, the two Cameco facilities (Blind River, Port Hope)
  - "emphasis on collaboration, cooperation, and transparency" between all three parties – the CNSC, the IAEA, and Cameco.
- Conceptualization, development, and implementation of safeguards at these facilities as a result of Policy Paper 18 "proceeded smoothly".
- CBR and CPH, as large throughput, long-running facilities that pre-date the application of safeguards, present unique challenges for the IAEA.
- Signatories to Additional Protocol

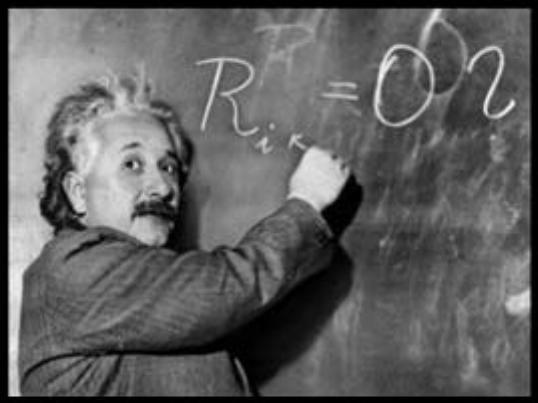
The Evolving Dynamic…



- **Dynamic between NWS and NNWS**
  - **Have/have nots: Additional Protocol**
- **What are the limitations and payoffs of the current and regimes**
  - **Why this not already in place?**
  - **Why now?**
  - **Implementation in current versus new facilities? Safeguards-by-Design versus retrofitting?**
- **How has and how should the role of safeguards in the NPT regime continue to evolve?**

Nuclear Engineers

What my friends think I do



What my mom thinks I do

What society thinks I do

What my boss thinks I do

What I think I do

What I actually do